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<u>SENT VIA EMAIL & FIRST-CLASS MAIL</u>

February 22, 2011

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State Water Resources Control Board
1001 I Street
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Re: San Joaquin River Flow Objectives
Need for Comprehensive Review of Information

Dear Board Members:

Pursuant to the Delta Reform Act of 2009, and Water Code section 85084.5, the California Department of Fish and Game ("DFG") was required to develop and recommend to the SWRCB Delta flow criteria and quantifiable biological objectives for species of concern in the Delta. In September 2010, a draft report was issued by DFG entitled "*CA Department of Fish and Game's Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta.*" ("Draft DFG Flow Criteria Report"). The Draft DFG Flow Criteria Report was released for public comment and was the subject of review by a peer review panel paid for by DFG but selected by UC Davis. Enclosed for your review is a copy of the peer review panel's comments on the Draft DFG Flow Criteria Report. I bring this to your attention because these comments, comprising only 13 pages, reveal a serious flaw regarding the way in which the SWRCB seeks, gathers, receives, accepts and uses information in the current process related to the SJR flow objectives.

To be blunt, the current SWRCB process, including the release of the Draft Technical Report ("DTR"), the request for and receipt of written comments, and the receipt of oral information at the two-day workshop in January, lacks scientific rigor. Any party, regardless of interest or qualification, is permitted to submit information to the SWRCB. Such information is not cross-examined by the SWRCB or its staff, is not submitted under penalty of perjury, or otherwise affirmed to be accurate. Any and all information,

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regardless of quality or source, is accepted by the SWRCB. While this ensures that the SWRCB receives a wide breadth of information, it does nothing to ensure that the information submitted is relevant, or more importantly, accurate.

The enclosed peer review comments to the Draft DFG Flow Criteria Report illustrate the SJRGA's concerns with the SWRCB process. In the Draft DFG Flow Criteria Report, DFG stated that flows in excess of 5,000 cfs were needed in April and May to keep water temperatures in the Delta at 65˚F for Chinook salmon, and that flows less than 5,000 cfs "may not be adequate to provide sufficient temperature conditions." (Draft DFG Flow Criteria Report, p. 49). The basis for this statement was Exhibit 3 submitted to the SWRCB in 2010 by The Bay Institute and the Natural Resources Defense Council. (Id.; see also p. 144). The peer review panel, however, found this statement to be unfounded, stating:

> "***The connection between Delta water temperatures and river flows is not established in the literature***. The criterion proposed here (flows>5000 cfs in April-May keep Delta water temperatures below 65 F) does not have any scientific criterion associated with it (in the Draft this criterion is based on testimony from the Bay Institute). Exploration of temperatures in the Delta and the connections to flows has been pursued in a fundamental sense by Monismith et al. (2008) and in view of the effects of climate change in a paper that is in review by Wagner et al. (part of the USGS CASCADE project)."(Peer review comments, p. 12)(emphasis added).

At least in terms of the alleged relationship between flows and temperatures in the Delta, the peer review panel found TBI's Exhibit 3 to be incorrect. Yet, TBI's Exhibit 3 was the basis of several of the written comments submitted by TBI regarding the DTR. (See December 6, 2010 TBI/NRDC comments on DTR, p. 6). And, to date, the written comments of TBI/NRDC, including the erroneous assertion of a relationship between SJR flow and Delta water temperatures, have been uncritically accepted by the SWRCB and its staff and comprise part of the administrative record for this process. Reliance by the SWRCB on this information in establishing SJR flow objective alternatives would be completely inappropriate.

The above is a very specific example of the much larger problem. As the peer review panel pointed out, the Draft DFG Flow Criteria Report was replete with information that was insufficient to support conclusions, including personal communications, unreviewed technical information, proposals for work not actually begun, and even misinterpretations of several important references. (Peer review comments, p. 13-15). The peer review panel also noted that many statements have no citations at all, including the assertion that "Flow related conditions are likely to be the major cause of this decline." (Id. p. 14). The peer review panel was especially critical of the lack of peer reviewed information, stating that "the use of non-peer reviewed information undermines much of the results presented." Finally, the peer review panel criticized DFG for not clarifying "the degree of certainty/uncertainty associated with individual flow objectives. Therefore it is not clear to what extent each individual objective is supported scientifically." (Id., p. 14). It is fair to presume that much of the information submitted to the SWRCB regarding the DTR suffers from these same flaws. Unfortunately, the SWRCB has no processes, mechanisms or procedures in place to ensure that its staff will thoroughly review, investigate, document and analyze the information submitted or its source.

Nor can the SWRCB rely upon the honesty, neutrality or even-handedness of its sister agencies to assist it in analyzing the accurateness and quality of the information submitted. Indeed, DFG's final Flow Criteria Report (p. 50-51) continues to assert the relationship between flow and temperatures in the Delta that the peer review panel determined to be unfounded. At least in terms of SJR flow recommendations, DFG is an advocate for a particular outcome to the same degree as any other interested party and its information and recommendations cannot be treated with any deference.

The DTR and the Draft DFG Flow Criteria Report contain many similar assertions and conclusions. This is not surprising, since much of the information relied upon in the Draft DFG Flow Criteria Report is the exact same material posted by the DFG and other interested parties in your Delta outflow proceedings. If you ask the authors of the DTR how much time was spent to review, document, analyze, and confirm source information, the answer would likely be "None."

I implore you to read the attached peer review comments in their entirety. It is not possible to have each piece of information submitted to you be peer reviewed, but the SWRCB must do something to ensure that the information it is receiving and relying upon is accurate, credible and correct. Certainly there will be differences in scientific opinion, and the SWRCB will need to use its judgment and discretion to address those differences. But the acceptance of incorrect information simply has no place in the SWRCB's consideration of alternatives to the current SJR flow objectives

Very truly yours,

O'LAUGHLIN & PARIS LLP

TIM O'LAUGHLIN

TO/tb
Enclosure

cc (via email only): SJRGA
Tom Howard
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Panel Review

of the

CA Department of Fish and Game's

Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta

Review Panel Members

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1. Introduction

This is a review of the September 3 draft report "Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta" (hereafter Draft), written by the California Department of Fish and Game. The report was mandated by the Delta Reform Act of 2009, specifically section 85084.5 of the Water Code:

> "The Department of Fish and Game, in consultation with the United States Fish and Wildlife Service and the National Marine Fisheries Service and based on the best available science, shall develop and recommend to the board Delta flow criteria and quantifiable biological objectives for aquatic and terrestrial species of concern dependent on the Delta. The recommendations shall be developed no later than 12 months after the date of enactment of this division."

At the outset, we wish to acknowledge the unrealistic difficulty of the task that the legislature gave to DFG in section 85084.5. This difficulty is recognized by Fleenor et al. (2010:2-3), who, as part of the State Water Resources Control Board's Delta Flow Criteria proceedings, developed some numerical estimates of flow standards for the Delta as examples of how standards might be developed, but cautioned that:

> "To support on-going policy and scientific discussions, we present four approaches for estimating fresh water flows needed to sustain viable populations of native fishes in the Delta. Using these approaches we demonstrate how illustrative quantities of water can be estimated. While these estimated flows might have some value in furthering discussions in light of the justifications and references provided, their greater value, for the time being, lies in comparing the approaches developed and applied here. Thus, although it may be tempting to grasp at these numbers, we emphasize this should be avoided in favor of developing alternative scientific and regulatory processes for prescribing defensible quantities of water on a renewable basis. This comparison is developed largely to facilitate more transparent and scientific discussion of desirable freshwater flows and to suggest potential methods for their estimation, including improvements on the methods presented here. We seek to organize this problem, *which cannot yet be solved*." (emphasis added)

In other words, Fleenor et al. (2010) opine that nobody yet knows how to do what the legislature directed DFG to do; we agree. Given this, it is not surprising that the DFG staff assigned to write the Draft appeared to struggle with it. Nevertheless, as we explain below, the Delta Reform Act sets a high standard for the report, which we felt obliged to apply in reviewing it.

We are also aware that we are late into the Delta flow criteria process, and were not part of State Water Resources Control Board's Delta Flow Criteria proceedings. Accordingly, we understand that there is a background to the DFG Draft of which we are only dimly aware, and that DFG participated in the Board's proceedings and provided input to the Board's August 3 report, "Development of flow criteria for the Sacramento-San Joaquin Delta Ecosystem." However, we read section 85084.5 as mandating that that DFG provide written recommendations to the Board that should stand on their own, and we review it from that perspective.

1.1 Definitions

To avoid potential confusion and miscommunication, we begin with some definitions of key words or phrases in section 85084.5, as we understand and use them. The section requires that DFG develop "flow criteria" and "quantifiable biological objectives." We take flow criteria to be numerical or potentially quantifiable standards for Delta inflows or outflows. By quantifiable standards, we mean flows sufficient to have some specified effect on biological resources that can be measured or modeled.[1] We take

[1] The familiar X2 criteria examples of quantifiable standards.

quantifiable biological objectives to be measurable variables that can be used as performance criteria, to determine whether the flow criteria are having the effects that they were expected to have.

Section 85084.5 mandates that the flow criteria and quantifiable biological objectives must be "based on the best available science." This reference to Best Available Science (BAS) is similar to language in the Endangered Species Act and derived documents, which we adopt, to normally involve peer review, scientific methodologies, logical conclusion and reasonable inferences, quantitative analysis, appropriate content and thorough references (VanCleve et al. 2004; Sullivan et al. 2006).

Furthermore, in our review we use the following language as defined in Lichatowich et al. (2005:10-11), but referring to DFG rather than NMFS:

> "We interpreted 'best' in terms of the normal scientific criteria: empirical support, consistency with information and theory generally accepted by leading scientists, relevance to the issue at hand, and professional reputation of the author. Based on guidance provided at the workshop by Penny Ruvelas of NOAA Fisheries, we take 'available' to mean information that NMFS biologists working in the Central Valley could reasonably be expected to be aware of, or could be expected to find with reasonable effort. This includes articles in major or regional journals; books published by major presses; reports by the National Research Council, by the other offices of NOAA Fisheries and other State and Federal agencies, and by major advisory committees that deal with management of Pacific salmon; and material presented at scientific meetings that are commonly attended by Central Valley salmon biologists (e.g., CALFED science conferences, Interagency Ecological Program and Modeling Forum annual meetings). Grey literature and unpublished reports by other state and federal agencies that deal with salmon in other geographic areas whose information was not widely reported in scientific journals would not be considered available."

We interpreted "using the best available scientific information" in terms of the following statements (from NRC 2004-a):

1) The agencies may not manipulate their decisions by unreasonably relying on some sources to the exclusion of others;
2) The agencies may not disregard scientifically superior evidence;
3) Relatively minor flaws in scientific data do not render the data unreliable;
4) The agencies must use the best data available, not the best data possible;
5) The agencies must rely on even inconclusive or uncertain information is that is the best available at the time of the decision;
6) The agencies cannot insist on conclusive data to make a decision;
7) The agencies are not required to conduct independent research to improve the pool of available data.

1.2. The Purpose and Use of Citations

The panel had many concerns about the use (or lack of use) of citations in the Draft, or about the citations used, so some comments on citations and their use seem in order. Citations serve various purposes, but in scientific writing the main purpose is to answer the question that readers should always ask: "why should I believe this?" The writer is implicitly making the statement: "This gives the reason(s) why I believe what I just wrote." In other words, the citation is supporting an argument, not establishing a fact. Citations, even to the peer-reviewed literature, are not like theorems in mathematics, and do not establish validity. For example, Stevens and Miller (1983) is in a peer-reviewed journal, but commits an elementary statistical error that vitiates its findings about the effects of Delta inflows on juvenile Chinook salmon (probably the authors and the reviewers missed the error because it was masked by the use of an index).

Someone citing the paper on this point (the Draft does not) would still have to accept responsibility for not reading it closely enough to notice the problem.

Thinking of citations as supporting an argument explains why citations to the peer-reviewed literature are preferred. They provide stronger support for an argument because independent people thought to be qualified are supposed to have read the papers carefully. Citations to agency reports provide weaker support, even if the reports are conceptually and technically sound, because they are not independently reviewed. Citations to personal communications generally provide even weaker support, unless the person cited is a recognized authority, etc. Good selection of citations also reassures the informed reader that the writer is knowledgeable about the area of science under discussion. Citation of the most current literature is generally a property of the best available science, because it presumably incorporates the cumulative state of peer-reviewed science and advances or even reverses the more contemporary paradigms based on new and more or superior evidence.

2. Suggested Approach to Address the Legislative Mandate

It is useful to review the mandate given to California Department of Fish and Game by the Legislature. Beyond Section 85084.5 (cited above), 85086(b) and 85086(c) stipulate

> "85086(b): It is the intent of the Legislature to establish an accelerated process to determine instream flow needs of the Delta for the purposes of facilitating the planning decisions that are required to achieve the objectives of the Delta Plan.
> (c) (1) For the purpose of informing planning decisions for the Delta Plan and the Bay Delta Conservation Plan, the board shall pursuant to its public trust obligations, develop new flow criteria for the Delta ecosystem necessary to protect public trust resources. In carrying out this section, the board shall review existing water quality objectives and use the best available scientific information. The flow criteria for the Delta ecosystem shall include volume, quality, and timing of water necessary for the Delta ecosystem under different conditions. The flow criteria shall be developed in a public process by the board within nine months of the enactment of this division."

Several points of this mandate should be emphasized:

- The mandate specifies use of "best available science" as discussed in the Introduction to this review document.
- The flow criteria should be developed for the "Delta ecosystem."
- Flow criteria and biological objectives should be developed for both aquatic and terrestrial species.
- The purpose of the flow criteria is to inform planning decisions for the Delta Plan and the Bay Delta Conservation Plan.
- The flow criteria should address the water needs of the Delta ecosystem "under different conditions" where we interpret 'different conditions' to be more than just different flow conditions.

This section discusses an approach that the Panel believes could have better addressed the mandate given to DFG by the Legislature by incorporating the best available science. However, the Panel also wishes to emphasize that it may not have been possible to meet the mandate given to DFG in the timeline specified by the Legislature. The simplified approach taken by DFG was no doubt strongly influenced by the timeline specified by Section 85084.5. However, even allowing for practical constraints, the panel finds that the Draft does not embody the best available science.

In the following sections, we comment briefly on a scientific approach that would have addressed the mandate.

2.1 The Draft should inform Delta Vision and BDCP

The Delta Vision and BDCP efforts have both employed a forward-looking, conceptual understanding of ecosystem function and interactions that involves consideration of a variety of future scenarios for Delta conditions. In order for the Draft to inform those efforts, it must employ a similar or comparable conceptual approach, including consideration of ecosystem landscape structure and the habitat needs of various species assemblages. Just as importantly, because the Delta Vision and BDCP are strongly focused on future scenarios for Delta conditions, it is critical that the Draft evaluate flow criteria and the connection to biological objectives in the context of future changes in Delta geometry, water management, sea level and other climate variability, such as precipitation and temperature (e.g., Malamud-Roam et al. 2007). Analysis that informs this process would necessarily be spatially explicit and developed in a way that allows evaluation of future scenarios. The requirement to evaluate future scenarios is explicitly called out in the mandate, where it is stated that the flow criteria be established for "the Delta ecosystem under different conditions."

2.2 The Draft should address the needs of the Delta ecosystem

The mandate explicitly calls for the flow criteria to establish the "water necessary for the Delta *ecosystem*." As such, we stress that a species-by-species focus is inappropriate, as this will not allow for consideration of trade-offs between components of the ecosystem, and it will not correctly establish the flow requirements of the ecosystem processes that support ecosystem goods and services, including species and their habitats. Instead, planning efforts must focus on the ecosystem distribution of habitats, the organization and connectivity among habitats, food web interactions among other aspects of the ecosystem, and consequently how critical ecosystem processes such as flows interact among these components.

2.3 The Draft should address the connections among flows and integrated aquatic and terrestrial species

The legislature specifically mandates that both biological objectives and flow criteria should be developed for terrestrial species as well as aquatic species. While there are biological objectives provided for terrestrial species, they are not well developed and additional focus and detail is required for them to be effective objectives. Perhaps more importantly, the flow criteria as developed in the Draft do not explicitly connect to the terrestrial species of concern. Following a more ecosystem-based approach (see 2.2), aquatic and terrestrial species should preferably be integrated into a community/habitat framework that considers trade-offs in flow responses of multi-species assemblages.

2.4 The Draft should embody an adaptive approach

Given the state of scientific understanding of the Delta and associated ecosystems, the Draft should describe salient known and relevant scientific uncertainties and apply an adaptive approach such as that described by Healey et al. (2008). Although the concept and definition of adaptive management has become very plastic (Poerksen 1995; Marmorek 2003), the Draft should have recognized that the setting of flows around predictable responses by species of concern involves considerable uncertainty which only an adaptive approach to conceptualizing, predicting (including modeling), experimenting and evaluating can resolve. The framework of the Sacramento River Ecological Flows Study Final Report (The Nature Conservancy et al. 2008) provides an exemplary example of the integrated trade-off analysis for select flow management alternatives (designed for use with the Sacramento River Ecological Flows Tool [SacEFT]) which is an explicitly adaptive approach required for these levels of scientific and technical uncertainty.

3. Comments on Approach Applied

As discussed in the previous section, we believe that the best available science would have involved a different set of analyses and approaches than was taken in the Draft. We understand the constraints on the process, however (as discussed in section 1), and in this section we comment on the specifics of the approach taken in the Draft, taking into account our understanding of the constraints. We divide these technical comments into those related to the scientific approach (section 3.1), the biological objectives (section 3.2), the flow criteria (section 3.3) and the Draft itself (section 3.4).

3.1 Best Available Science and Its Application

This section is intended to provide general feedback on what is involved with both applying and presenting the best available science.

- Critical assumptions and areas of major uncertainty are not described.
- Methodology for monitoring results and adaptive strategies to respond to emerging results are not described.
- References must be accurately cited. It is the responsibility of the authors to ensure that they are correctly citing facts, results or conclusions from particular references and attributing them correctly. There are a number of examples in the Draft (discussed below in section 4.4.1) where a conclusion or fact is attributed incorrectly to a particular reference, which leaves the statement without a scientific basis.
- References must be clearly cited. Relying on references that are "personal communication" or obscurely cited ("NMFS 3 in SWRCB 2010") makes it difficult to evaluate the underlying science.
- Whenever possible, references should be to peer-reviewed literature, not internal technical reports or testimony. In many cases, this will require that the authors trace back through the literature to determine the original source of the information, but that is part of providing BAS.
- The Draft frequently relies on some sources to the exclusion of scientifically superior sources. As three examples, it cites outdated analyses by Kjelson and Brandes instead of superior analyses (Newman and Rice 2002; Newman 2003). It cites an outdated study by Brett (1952) and a consulting report and testimony by Alice Rich on the temperature tolerance of juvenile salmon instead of scientifically superior studies by Myrick and Cech (2001, 2002, 2004) and Marine and Cech (2004). It relies on an unpublished work by Marston and ignores superior studies by Newman[2] and others involved with VAMP, and by Terry Speed (1993). It fails to cite many relevant, more recent papers (Appendix A3), including a long review on Central Valley Chinook and steelhead (Williams 2006) that would have drawn DFG's attention to the superior sources just noted.
- The Draft refers to a vague source (DFG 2010a) on key points, such as "Random rare and unpredictable poor ocean conditions may cause stochastic high mortality of juvenile salmon entering the ocean, but the overwhelming evidence is that more spring flow results in higher smolt abundance, and higher smolt abundance equates to higher adult production (DFG 2010a)" at p. 47. This sentence is also misleading; it is true that rare ocean conditions can cause high mortality of juvenile salmon entering the ocean, but so can more common conditions. This claim seems to be an attempt to defend the Marston results from the criticism that fitting models to smolt-adult survival data without taking variable ocean survival into account will give misleading results (a claim that is dubious to start with, but even more so without a supporting reference).

[2] Newman, Ken B. 2008. An evaluation of four Sacramento-San Joaquin River Delta juvenile salmon survival studies. USFWS, Stockton.

- The Draft does not acknowledge the uncertainty associated with most of the modeling work referred to in the Draft, including the water quality and particle tracking modeling work.
- The Draft suggests that much is known concerning the behaviors of salmonids (e.g. vertical position as a function of time of day) and other species. In this case, three-dimensional particle tracking models with representation of behavior or full individual based models may be useful to understand effects of proposed modifications to Delta geometry and operations (e.g., Goodwin et al., 2006).
- As part of future modeling efforts, particle tracking models used for these studies should be evaluated by comparison with appropriate surface drifter observations. In addition ensemble modeling approaches and Bayesian inference should be used to provide insight to the uncertainty of model predictions.

3.2 Biological Objectives

3.2.1 General Comments

- The Draft does not reflect current Delta planning criteria. Although it is difficult to interpret just how much of the proposed Draft is predicated on meeting the directives of the many Bay-Delta planning documents described in the Draft's *Planning Efforts* section (3), much of it does not appear to reflect the explicit intent of the *Delta Vision*. For instance, one of the more pertinent goals from the Delta Vision Strategic Plan (2008) is Goal 3, including four of five strategies (the fifth addresses improvement of water quality to meet drinking water, agriculture, and ecosystem long-term goals) that directly address habitat and natural ecosystem process restoration needs (included in Appendix A1). The most important message in the comprehensive approach of this Delta Vision goal is that restoring delta flows and channels is only <u>one</u> of four strategies that are considered essential to restoring the Delta's ecosystem(s): The other three argue for: (1) restoring large areas of interconnected habitats within the Delta and its watershed; (2) establishing migratory corridors for fish, birds and other animals along selected Delta river channels; and, (3) promoting viable, diverse populations of native and valued species by reducing risk of fish kills and harm from invasive species.
- For many species, the Draft seems to assume that flow alone will restore natural processes and restore/reconnect critical habitats for these species. This assumption is poorly founded.
- Similarly, hypothesized responses by species and species assemblages should have been placed in context of DRERIP conceptual models (see: <u>http://science.calwater.ca.gov/drerip/drerip_index.html</u> for peer-reviewed models and documentation; these models are being prepared for future publication in *San Francisco Estuary and Watershed Science*).
- While the biological objectives are appropriate at the generic species requirement level, and particularly where flow criteria relate most directly to pelagic species (Delta smelt; longfin smelt; splittail; American shad; *Eurytemora affinis*), they are insufficient when addressing the habitat network required to sustain populations seeking to rear or permanently occupy their habitats in the Delta.
- The Draft does not address the effects of climate change on the Delta ecosystem or flows. At a minimum, the Draft should acknowledge the uncertainty created by climate variation in the coming decades for both the biological processes being discussed and California's hydrology.
- A number of objectives and approaches/methods should be added to address how changes in flow criteria should naturally inundate expanded habitat mosaics and corridors across/through the Delta. These should relate the occurrence and timing of critical spawning, rearing and migration patterns through the Delta.

- The explicit habitat goals in the Draft, which are treated separately from either terrestrial or aquatic biological goals, are vague. These goals are placed in two categories:
  1. Under Biological Objectives for Terrestrial Species of Concern (6.27, NOT under Biological Objectives and Flow Criteria for Aquatic Species of Concern!);
     - Protect, enhance, restore, and develop intertidal habitat and associated sub-tidal habitat within the Bay-Delta to improve habitat and food web support for species of concern.
  2. Under Summary for Biological Goals and Objectives for Terrestrial and Aquatic Species (9.2.4);
     - Protect, enhance, and restore the habitat functions and values of wetlands and agricultural lands within the Delta and Suisun Marsh for waterfowl, shorebirds, and waterbirds as described in the 2006 Central Valley Joint Venture Implementation Plan.
     - Maintain alkali seasonal wetlands with improved native biodiversity, habitat heterogeneity, and the ability to support populations of covered and other native species.
     - Protect, enhance, and restore vernal pool habitat communities that support habitat for covered and other native species.

  Even though biological goals for aquatic species are the most developed in the Draft, the goals for fish habitat are typically vague and ill-defined beyond water characteristics of salinity, temperature and turbidity. There are few explicit descriptions of ecological habitat goals that would constitute quantitative indicators of species' spawning sites, rearing habitats or migratory corridors in Delta channel and shallow water ecosystems.
- Several biological objectives are qualitative. Section 85084.5 calls for quantifiable objectives.
- When a biological objective involves achieving a recovery goal or another change in conditions, a date for achieving the objective is appropriate.
- The criterion for contaminants (Section 7.3.2) is too broad and vague to be effective.
- Overall, the Draft is inadequate in its identification and discussion of the effects of Delta flow on the impacts of pollutants on aquatic life resources in the Delta. For more information on the issues that need to be considered in establishing Delta flow criteria that more reliably consider the implications for and effects of the impacts of pollutants, we refer to the Lee and Jones-Lee 2010 reports submitted to the SWRCB in its Public Trust Delta Flow Criteria.

3.2.2 Detailed Comments

- The basic (not necessarily the Delta-specific) information on coastal wetland requirements and use by juvenile Chinook salmon is relatively parochial and out of date. There has been considerable information emerging over the past decade that continues to validate at least two relevant aspects of their life history:
  - Life history diversity of Chinook salmon, whether genetic or tactical, is influenced by habitat diversity and opportunity and is considered important to population resilience; and,
  - Several life history types express strong fidelity toward prolonged estuarine wetland occupancy, fidelity toward particularly geomorphic habitat features and specific locations, and selectivity toward particular estuarine food web pathways.
  - Miller et al. (2010) provide evidence that a substantial proportion of juvenile Central Valley fall Chinook leave fresh water at <56 mm fork length. Given that most Central Valley fall Chinook are hatchery fish, as shown by Barnett-Johnson et al. (2005) and the proportion of marked fish observed in the 2009 carcass surveys, and that fish leaving fresh water at < 56 mm are unlikely to be hatchery fish, juveniles that leave fresh water before they reach "smolt" size may be the dominant part of the naturally produced fraction of the run. The objectives in the Draft ignore these fish.

- In 6.26 the objective "Protect, enhance, and restore the habitat functions and values of tidal, permanent, and seasonal wetlands and agricultural lands within the Bay-Delta for waterfowl, shorebirds, and waterbirds" is too vague to be useful. This objective could summarize and cite relevant DRERIP conceptual models (see 3.2.1).
- The objectives for salmon fail to distinguish hatchery and naturally produced fish. The objectives refer to the salmon protection water quality objective, which seems to be: "Water quality conditions shall be maintained, together with other measures in the watershed, sufficient to achieve a doubling of natural production of Chinook salmon from the average production of 1967-1991, consistent with the provisions of State and federal law." There is a key phrase in this language, "natural production," that is defined in the CVPIA. This excludes hatchery-reared salmon. The Draft does not deal with the difference between hatchery and natural production of salmon and steelhead.
- The first three objectives embody the notion that river flows "transport salmon smolts through the Delta." As discussed in Ch. 6 of Williams (2006), the migration of juvenile salmon is much more complicated than this and for most juvenile Chinook life history types cannot, and should not, be separated from rearing in the Delta.
- "Biological Objectives and Flow Criteria for Aquatic Species of Concern" includes a Subsection — "7.3 Other Factors," which incorporates a section on page 93 of "7.3.2 The Effect of Contaminants on Fish." That section presents information on potential impacts of ammonia on selected Delta fish species; much of the discussion focused on the writings of P. Gilbert (2010). A critical review of the information on the potential impacts of ammonia on water quality in the Delta shows that it is inappropriate to single out the statements by Gilbert without discussing the comments of others such as J. Cloern[3] of the USGS that discuss the unreliability of the Gilbert approach for evaluating the potential impact of ammonia in impacting Delta aquatic life resources.
- Despite on the forgoing information for nutrients, the discussion in Section 7.3.2, *DFG* Recommended Biological Objective recommended:

  > "Prevent the discharge of pollutants at concentrations that are acutely or chronically toxic to fish."

  However, no mention is made in this section devoted to *The Effect of Contaminants on Fish* of the need for flow criteria to control/minimize the impact of the flow of water into and within the Delta to mitigate the impacts of pollutants added to the Delta waters that are adverse to the biological resources of the Delta. The DFG recommended biological objective of preventing the discharge of pollutants that cause acute and chronic toxicity to fish is already a long standing requirement of the Clean Water Act and the SWRCB and CVRWQCB Basin Plan Objectives for the Delta and all Central Valley waters. This DFG biological objective fails to provide the guidance that is needed to protect fish and other public trust aquatic life resources of the Delta from the impacts of pollutants.

3.3 Flow Criteria

3.3.1 General Comments

- In developing a set of flow requirements using the functional flows approach, the biases and uncertainties in the approach *must* be explicitly discussed and quantified. Because functional flows rely on constructing the aggregated flows from those required for a wide array of processes, if any process or mechanism is left out – either due to oversight or an

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[3] Cloern, James "Historical Perspective on Human Disturbance in the Sacramento-San Joaquin Delta Ecosystem", Senior Research Scientist, U.S. Geological Survey Menlo Park, CA presented at National Academies of Science (NAS) National Research Council (NRC) meeting, "**Sustainable Water and Environmental Management in the California Bay-Delta**" held on July 13-15, 2010 in Sacramento, CA. PowerPoint slides obtained from the NRC Public Access Records Office at www.nrc.gov/reading-rm/foia/foia-privacy.html.

incomplete understanding – the resulting aggregated functional flow will be an *underestimate* of the required environmental flows, which will create a biased estimate of the required flows. At the same time, it is critical to acknowledge and quantify the uncertainties associated with the flow criteria. This should be explicitly acknowledged. Key sources of uncertainty should be discussed methodically for each flow criterion. This is particularly important when aggregating to define the total "functional flows" so that an appropriate margin of error can be provided – both technically and in the political process. Without an analysis of bias and uncertainty, the accuracy and scientific merit of the functional flow estimate will be overstated.

- The approach of the Draft implicitly takes the view that more outflow is always better for all species with very little discussion of potential ecological trade-offs. For example the stipulated fall outflows that are believed to benefit delta smelt may also benefit certain invasive species such as the overbite clam.
- When statistical relationships are described (e.g., Vernalis flows and cohort return ratios of San Joaquin River Chinook salmon), it is appropriate to report measures of sample size and uncertainty.
- Existing statistical relationships may in some cases provide the best basis for flow standards for the current Delta geometry (for example, the reliance on X2 to define the flow criteria for the majority of species). However these relationships may not remain valid in the future as the Delta is modified by restoration, levee failure, changes in operations and climate variability. For example, the empirical regression model for fall-run Chinook salmon production described on page 50 might be appropriate for current conditions but is likely to be inadequate for some future scenarios. An essential contribution of the best available science approach would conceptualize and predict what species and communities would be able to express in terms of beneficial use of Delta under different flow and restoration scenarios rather than what they are only capable of doing at present. It would therefore be useful for the Draft to discuss a methodology for updating flow standards to apply for future scenarios.
- Year-to-year variability to meet biological objectives is missing, or is based on water year type. If we are to use functional flows, then the water year type should not be a factor – the biological requirements should be independent of the hydrology. If there is a need for year-to-year variability, then this should be stated as such (this is something that Fleenor et al. (2010) did very well). The biological objectives and required flows should not depend on the specific realization of hydrologic flows. To be clear, if we have 10 straight wet years, or 10 straight dry years, the required flows for meeting the biological objectives will be incorrect. It is possible that the DFG was using criteria based on water year type to create year-to-year variability, but the scientific basis for this approach is not established. To built this up scientifically, the authors would need to (a) define what degree of year-to-year variability in flows benefits the species (not done in the Draft); (b) establish the temporal variability of year types in the historical record (also not done here, but analysis exists); and (c) develop projections of the frequency of water year types for future conditions (the CASCaDE project the USGS has been pursuing may inform this).
- Most of the particle tracking modeling referred to in the Draft was conducted with the DSM2 PTM. This particle tracking model has been used in the Delta with minimal calibration/validation. The good performance of the DSM2 hydrodynamic model does not insure acceptable performance of the DSM2 PTM because the formulation of the DSM2 PTM makes several assumptions in interpretation of the DSM2 hydrodynamic results and relies on site-specific empirical parameters (not contained in the DSM2 hydrodynamic model) describing vertical and lateral variability of velocity. Therefore, the accuracy of the DSM2 PTM is not well established. Some insight to the performance of the model is provided by the intermodel comparison in Gross et al. (2009) and further discussion is included in Appendix A2.
- In the DFG report, there was no discussion of the fact that errors in estimating the required flows can create irreversible changes in the ecosystem. This creates an asymmetric impact

of errors in the flow volumes; specifically, overestimating environmental flow requirements is much less likely to create irreversible change than would an underestimate. This should be in the discussion of tradeoffs between ecosystem and human water needs if we are to truly consider them co-equal partners.

- The Draft Executive Summary recognizes some elements of the importance of flow in its statement:

  > "Water flow through the Delta is one of the primary drivers of ecosystem function. The timing, magnitude, and quality of flows all influence habitat features such as temperature, turbidity, transport, nutrient loadings, pollutant dispersal, and other factors."

  The draft report fails to address the issues of impacts of flow on nutrient loadings and aquatic plant growth/presence on habitat, pollutant dispersal/impact location and magnitude, and other factors such as habitat characteristics including the hydraulic residence time of water in a channel such as the SJR Deep Water Ship Channel that impacts DO depletion and the ability of fall run Chinook Salmon to migrate through the DWSC to their spawning areas in the SJR watershed.
- Perhaps the flow criteria recommendations address the requirements in Water Code 85084.5 from the perspective of 'shuttling' individual species around the estuary, but they do not from the standpoint of providing significantly increased areas and connectivity of Delta habitats. Accordingly, the methods used to develop the flow criteria are seemingly sound for relating individual species requirements for positioning in Delta, but not from the standpoint of increasing opportunity and capacity to occupy rearing, migration and reproduction habitats. Thus, the data and information used to develop the Draft's assessment is germane for the pelagic, including POD, species, but not for the ecosystem benefits of wetland habitat restoration to the food web pathways supporting many POD species, nor for other species and communities requiring shallow water habitats.
- It is not possible to determine whether the flow criteria are adequate to elicit beneficial ecological responses without commensurate analysis of habitat network/mosaic restoration and reconnection. The Delta needs to be viewed and analyzed as a hydrodynamic system more than just discrete statistical relationships among physicochemical parameters and fish occurrence and abundance.
- One of the more important flow criteria should be shallow water habitat inundation frequency and duration in different hydrogeomorphic domains in the Delta. Flow regime scenario 'trade-offs' need to be compared between (current) objectives based on 'shuttling' and 'positioning' species around Delta and inundation of shallow water habitat and corridors.
- Performance measures that should be considered to determine if the flow criteria are meeting the objectives (i.e., doubling goal, 1996 USFWS Recovery Plan, etc.) could include:
  - Species residence times and performance (reproduction, feeding and reproductive success, survival)
  - Assemblage composition and biodiversity
- On page 104 of the Draft, the summary subsection, 9.2.5 Aquatic Species Biological Objectives includes the following under the heading "Other Factors":

  > "Nutrients and other pollutants
  >
  > - Prevent the discharge of pollutants at concentrations that are acutely or chronically toxic to fish.
  > - Determine the effect of ammonia on the nutrient dynamics of the Delta."

As discussed herein, flow into and through the Delta channels has significant impacts on many known, as well as unregulated and unrecognized, pollutants besides ammonia. This is an unjustifiably narrow scope in consideration of impacts of pollutants on fish in the Delta, and the influence of flow on those impacts. As discussed and documented in the Lee and Jones-Lee reports submitted to the SWRCB in its Public Trust Delta Flow Criteria Development process, the diversion of flow upstream of and within the Delta significantly impact aquatic life and other public trust resources of the Delta. The amount, timing, pattern, and location of water diversions affect the transport and transformation of pollutants (including aquatic plants); affect the nature, extent, location(s), and significance of the manifestation of pollutant impacts; and affect biological, physical, chemical, and habitat conditions within the Delta channels that influence the manifestation of impacts of pollutants on aquatic life and public trust resources of the Delta.

> Lee, G. F., and Jones-Lee, A., Discussion of Water Quality Issues That Should Be Considered in Evaluating the Potential Impact of Delta Water Diversions/Manipulations on Chemical Pollutants on Aquatic Life Resources of the Delta. Submitted to CA State Water Resources Control Board as part of Public Trust Delta Flow Criteria Development, by G. Fred Lee & Associates, El Macero, CA, February 11 (2010a). http://www.gfredlee.com/SJR-Delta/Impact_Diversions.pdf (Water Diversion Impacts)

> Lee, G. F., and Jones-Lee, A., Comments on Water Quality Issues Associated with SWRCB's Developing Flow Criteria for Protection of the Public Trust Aquatic Life Resources of the Delta. Submitted to CA State Water Resources Control Board as part of Public Trust Delta Flow Criteria Development, by G. Fred Lee & Associates, El Macero, CA, February 11 (2010b). http://www.gfredlee.com/SJR-Delta/Public_Trust_WQ.pdf (Impact of flow)

The export project manipulations of Delta flows not only impact the occurrence and frequency of low-DO conditions, but also the locations at which low DO occurs in the Delta relative to sensitive fisheries habitat and hence the impact that low-DO conditions and toxic pollutants have on Delta aquatic life resources. Table 16: DFG Flow Criteria (San Joaquin River, pp. 106-107 of the Draft) fails to mention the need for adequate flows of the SJR through the DWSC and south Delta Channels in order to greatly reduce/eliminate the low-DO conditions that are occurring in these areas. All of these issues should be discussed in the Draft.

3.3.2 Detailed Comments

- The connection between Delta water temperatures and river flows is not established in the literature. The criterion proposed here (flows >5000 cfs in April-May keep Delta water temperatures below 65 F) does not have any scientific citation associated with it (in the Draft this criterion is based on testimony from the Bay Institute). Exploration of temperature in the Delta and the connection to flows has been pursued in a fundamental sense by Monismith et al. (2008) and in view of the effects of climate change in a paper that is in review by Wagner et al. (part of the USGS CASCaDE project).
- Spatial and temporal distribution of flows. We see no scientific basis for the criterion "Inflows should generally be provided... in proportion to their contribution to unimpaired flow in order to assure connection between Delta flows and upstream tributaries." It is not clear that it would be ecologically beneficial if tributaries provided flow in proportion to unimpaired flow because these tributaries, and the Delta, are highly modified. Therefore providing a more natural distribution of inflows will not necessarily provide beneficial flow patterns or habitat conditions in the Delta.
- Similarly, the criterion that "to the extent possible, flow criteria should reflect the frequency, duration, timing, and rate of change of flows, and not just volumes or magnitudes" is too broad and general to be useful. Providing criteria for specific hydrograph features on specific tributaries would be more useful.
- The scope and approach of the DO modeling on the San Joaquin River (page 53) is not described. The citation (NMFS 3 as cited by SWRCB 2010) was not clear because the NMFS citations in the SWRCB (2010) document are provided by year (e.g., NMFS 2005).
- No description or citation is provided for the "habitat modeling" of the San Joaquin River tributaries mentioned in the last sentence on page 53.
- Incomplete discussion of modeling (top of p.6) "During 2008 and 2009, modeling to evaluate conveyance operations of the options and a detailed draft conservation strategy is due in the Fall

of 2010." Who is doing this modeling? When will results be available? How will they be incorporated into management?

- Some processes are not included in flow criteria. Following table 2, there is discussion of some benefits to some species of episodic high flows and yet those flows don't seem to appear in the flow criteria. This will clearly lead to an underestimate of the required flows (as discussed above in Section 3.3.1).
- No details are discussed relevant to the particle tracking simulations discussed on page 55. A minimum set of relevant information should include which model was used, the behavior associated with particles (if any), the release locations and times and the duration of the simulation. Several of the documents references (e.g. SJRGA) are difficult to track down. These documents should be made readily available to reviewers. It is not clear which document is referred to as NMFS 3 as cited in SWRCV 2010. The NMFS (2009) reference discusses some DSM2 particle tracking model (PTM) simulations. Details of the DSM2 PTM simulations are not discussed. Specifically, it is not clear if passive particles were used or if some behavior was applied to the particles. The salmonid behaviors described by DFG could have a large influence on pathways of salmonids (e.g., Goodwin et al. 2006). It is unlikely that the effect of these behaviors can be represented adequately in DSM2 PTM, which is based on one-dimensional hydrodynamic results from the DSM2 model. Two-dimensional and three-dimensional particle tracking models would be more appropriate for salmonid studies.
- The DFG 2009b reference provided some information about particle tracking modeling related to longfin smelt. Longfin smelt are understood to be surface oriented. The effect of vertical position is represented crudely by the DSM2 PTM because the hydrodynamics for DSM2 are one-dimensional. Most importantly, vertical position (and lateral position) is NOT considered in estimating the trajectory of a particle at a junction in the DSM2 PTM. Instead, when a single DSM2 channel (A) splits into two channels (B and C), the proportion of particles that enters each of the channels is proportional to the flow in the individual channels. For example, if the flow in A is 100 cfs, in B is 90 cfs and in C is 10 cfs, then 90% of the particles leaving channel A will enter channel B at the junction. Vertical variability in velocity is considered by DSM2 in channel (not junction) segments. However, the assumptions used to estimate a vertical velocity profile are crude and only apply strictly to steady uniform channel flow. They do not account for lateral velocity, effects near junctions, stratification, tidal accelerations, etc. A three-dimensional hydrodynamic and particle tracking model approach is more appropriate for surface oriented particles.
- On page 82, the Draft states that the habitat relation of American shad was defined by salinity and Secchi depth in Kimmerer et al. (2008). The modeling work in Kimmerer et al. (2008) did not predict turbidity (Secchi depth), only salinity and water depth, and the predicted habitat area for different X2 was defined only in terms of salinity and water depth. Kimmerer et al. (2009) did evaluate whether observed American shad abundance was related to observed Secchi depth and other variables and found that salinity explained most of the variability in observed abundance. This analysis justified omitting Secchi depth from the habitat area calculations.

3.4 Document and Presentation

- It is important that the Draft not attempt to balance the competing needs for water supply. We fear that this is the motivation behind flow criteria that depend on year-type (discussed above). If the environment and other uses are to be co-equal partners, then the Draft *must* present the actual flow criteria and requirements regardless of the available supply. The discussion of trade-offs and balancing between competing needs is a political process for which this report is input.
- Relevant recent scientific studies are not included, such Monismith et al. (2009).
- The use of testimony (unavailable for review – or at least difficult to track down) or another unreviewed technical report (SWRCB 2010) is not enough to justify conclusions. In one case (for the flow requirement to prevent flow reversal at Georgiana Slough), a fact is attributed to the SWRCB report, but in that report the fact is referenced to "personal communication" or to some

testimony that is unavailable for review. Other examples include references to Snider and Titus (DFG technical reports), Allen and Titus (which is actually a proposal!) and testimony from groups like American Rivers or the Natural Heritage Institute. To ensure scientific transparency, references should be given to their original source. Otherwise, a personal communication or a proposal begins to have the appearance of a reviewed scientific reference.

- Statements without scientific references are sprinkled throughout the Draft. One example lies in the statement that as natural flows have been reduced, flow conditions have become more favorable to non-native species. While this might be true, the inclusion of the modifier "flow" on "conditions" makes it a more specific statement than is likely to be defensible scientifically (i.e., the more vague statement "...as natural flows have been reduced, conditions have become more favorable to non-native species" is probably better established in the literature). As a second example, the discussion of the decline in San Joaquin River Chinook from 26000 to 13000 states "Flow related conditions are likely to be a major cause of this decline," but there is no reference to support the statement. Further, the use of non-peer-reviewed information undermines much of the results presented. The flows required to prevent salmon entrainment at Georgiana Slough, for example, are referenced from Perry et al. 2008 and 2009, but these are just technical reports, and have not been peer-reviewed; at least some of this work has been published and that should be cited.
- In most cases the report does not clarify the degree of scientific certainty/uncertainty associated with individual flow objectives. Therefore it is not clear to what extent each individual objective is supported scientifically.
- Minimal detail of relevant modeling studies has been provided. In any case where flow criteria have been based in part upon modeling studies, the modeling studies should be briefly described in the Draft. Direct references of relevant papers and reports should be provided.
- The Draft provides both goals and objectives, while Section 85084.5 calls only for objectives. This makes the meaning of the words "goals" and "objectives" in the draft unclear.
- The Draft should clarify which stated objectives/criteria are taken from other sources (e.g. the ERP Plan for terrestrial species) and which are "new" objectives.

3.4.1 Specific Concerns with Referencing

- There are a number of cases where the actual sources of a piece of information are inaccurately referenced – at times in ways that are quite deceiving. For example, the Draft attributes population declines since 1985 to flows based on Fleenor et al. (2010). Fleenor et al. (2010) do not make that statement. (It is bad enough that such a fundamental point to this whole process is being based on an unreviewed document.). They do compare 1949-1968 ('when fish were doing better') to 1986-2005 ('when fish were doing poorer') and note that the flows have changed – but they do ***not*** conclude that this is causative.
- In the first paragraph of page 75, an entrainment loss estimate of up to 40% was attributed to "PTM results" by Kimmerer (2008). The bulk of the entrainment losses estimated in Kimmerer (2008) were estimated based on survey observations, flow observations and several assumptions. Figure 16 and a small part of the text discuss particle tracking model results which estimate percent loss to the population. However, it should be noted that this is assuming no natural mortality. Kimmerer (2008) also estimates population losses by a more complete method which does take account of natural mortality but does not utilize any particle tracking results. These (lower) estimates are more appropriate to cite, preferably noting that the estimated error bounds for the calculated population losses are quite large.
- It is not entirely clear in which cases the Biological Objectives and Flow Criteria have been directly adopted from other documents such as the ERP Plan or OCAP (NMFS 2008). This should be clarified for each Biological Objective and Flow Criteria.
- The report commonly references SWRCB 2010 and DFG 2010a. SWRCB 2010 refers to the State Water Resources Control Board document. Some of the information in that document is associated with an information proceeding. This document summarizes existing information and

scientific understanding. DFG 2010a refers to the participation of CDFG in the State Water Resources Control Board Informational Proceeding. Whenever possible original scientific literature should be cited as opposed to summary documents.

- Fleenor et al. (2010) is referenced frequently when the citation should have been to the original scientific source material, especially when this was a peer-reviewed journal publication.
- The Draft misinterprets several important references. For example, at p. 40: "Based on the mainly oceantype life history observed (*i.e.*, fall-run), MacFarlane and Norton (2002) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry." The first clause in this sentence is incorrect; MacFarlane and Norton (2002) were contrasting their results with those from other ocean-type populations of Chinook. Moreover, MacFarlane and Norton (2002) defined the estuary in terms of salinity, rather than tidal influence, so their study applies only to the bays, not to the Delta. Further, their data collection did not begin until late spring, whereas most naturally produced fall Chinook move into the Delta in winter or early spring.
- A large section of text regarding salmon (pp 36-39) that contain errors and poor scholarship, including the misreading just discussed, was taken from the 2009 OCAP BO without attribution. The Draft does note that "Much of this section is excerpted and adapted from DFG (2010a, 2010b) and SWRCB (2010)," and indeed much of the language also appears in SWRCB (2010). It does not seem, however, that the language was original with DFG, as suggested by the reference to DFG (2010a; 2010b), which were submissions to the process resulting in SWRCB (2010). We realize that Section 85084.5 directs DFG to develop its recommendations to the SWRCB in consultation with NMFS, but this is carrying consultation too far, and violates ordinary standards for scientific writing.

4. References Mentioned in Draft but not Cited:

Barnett-Johnson, R., C.B. Grimes, C.F. Royer and C.J. Donohoe. 2007. Identifying the contribution of wild and hatchery Chinook salmon (*Oncorhynchus tshawytscha*) to the ocean fishery using otolith microstructure as natural tags. Can. J. Fish. Aquat. Sci. 64:1683–1692.

Fleenor, W.H., Bennett, W.A., Moyle, P.B., Lund J.R. 2010. On Developing Prescriptions for Freshwater Flows to Sustain Desirable Fishes in the Sacramento-San Joaquin Delta, PRELIMINARY DRAFT, Center for Watershed Sciences, University of California, Davis.

Goodwin, R.A., Nestler, J.M., Anderson, J.J., Weber, L.J., and Loucks, D.P. 2006. Forecasting 3-D fish movement behavior using a Eulerian-Lagrangian-agent method (ELAM). Ecological Modelling. 192, 197-223.

Gross, E.S., MacWilliams, M.L., Holleman, C.D., and Hervier, T.A. (2010). POD 3-D Particle Tracking Modeling Study, Particle Tracking Model Testing and Applications Report, http://www.science.calwater.ca.gov/pdf/workshops/POD/GrossEtAl_POD3D_Particle_tracking_2010.pdf

Healey, M.C., Dettinger, M.D., and Norgaard, R.B. 2008. The state of Bay-Delta science. CALFED Science Program.

Kimmerer, W.J., Gross, E.S. and MacWilliams, M.L., 2009. Is the Response of Estuarine Nekton to Freshwater Flow in the San Francisco Estuary Explained by Variation in Habitat Volume? Estuaries and Coasts, 32(2), 375-389.

Lichatowich, J., Anderson, J., Deas, M., Giorgi, A., Rose, K., Williams, J. 2005. Review of the Biological Opinion of the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan. Prepared for the CALFED Bay-Delta Authority.

Malamud-Roam. F., M. Dettinger, B.L. Ingram, M.K. Hughes and J.L. Florsheim. 2007. Holocene Climates and Connections between the San Francisco Bay Estuary and its Watershed: A Review. San Francisco Estuary and Watershed Science 5, Article 3 (http://repositories.cdlib.org/jmie/sfews/vol5/iss1/art_3.

Marine, K.R., Cech, J.J. Jr. 2004. Effects of high temperature on growth, smoltification, and predator avoidance in juvenile Sacramento River Chinook salmon. North American Journal of Fisheries Management 24:198-210.

Marmorek, D. 2003. What is adaptive management? Presented in: Making it work: strategies for effective adaptive management workshop, City of Seattle and Washington Trout, February 13–14, 2003, Seattle.

Monismith, S.G., Hench, J.L., Fong, D.N., Nidzieko, N.J., Fleenor, W.E., Doyle, L., and Schladow, S.G. 2008. Thermal variability in a tidal river, Estuaries and Coasts, Vol. 32, No. 1, pp. 100-110, DOI 10.1007/s12237-008-9109-9.

Myrick, C.A., Cech, J.J. Jr. 2001. Temperature effects on Chinook salmon and steelhead: a review focusing on California's Central Valley populations. http://www.cwemf.org.

Myrick, C.A., Cech, J.J. Jr. 2002. Growth of American River fall-run Chinook salmon in California's Central Valley: temperature and ration effects. California Fish and Game 88:35-44.

National Research Council (NRC). 2004-a. Improving the Use of the "Best Scientific Information Available" Standard in Fisheries Management. National Academies Press, Washington, DC.

Newman, K.B. 2003. Modelling paired release-recovery data in the presence of survival and capture heterogeneity with application to marked juvenile salmon. Statistical Modelling 3(3): 157-177.

Newman, K.B., Rice J. 2002. Modeling the Survival of Chinook Salmon Smolts Outmigrating Through the Lower Sacramento River System. Journal of the American Statistical Association 97(460): 983-993.

Perry, R.W., Skalski, J.R. 2008. Survival and Migration Route Probabilities of Juvenile Chinook

Salmon in the Sacramento–San Joaquin River Delta during the Winter of 2007-2008. Final Report Submitted to U.S. Fish and Wildlife Service.

Poerksen, U. 1995. Plastic Words: The Tyranny of a Modular Language. Transl. J. Mason and D. Cayley, Penn. State Univ. Press, Univ. Park, Penn.116 pp.

Speed, T. 1993. Modeling and managing a salmon population. In: Barnett, V., Turkman, K.F., editors. Statistics for the Environment. John Wiley & Sons. p. 265-290.

Stevens, D.E., and L.W. Miller. 1983. Effects of river flow on abundance of young Chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin river system. N. Am. J. Fish. Mgmt. 3:425-437.

Sullivan, P.J., L.M. Acheson, P.L. Angemeler, T. Faast, J. Flemma, C.M. Jones, E.E. Knudsen, T.J. Minello, D.H. Secor, R. Wunderlich, and B.A. Zanetell. 2006. Definiting and implementing best available science for fisheries and environmental science, policy and management. Fisheries 31: 460-465.

The Nature Conservancy, Stillwater Sciences and ESSA Technologies. 2008. Sacramento River Ecological Flows Study: Final report. Prepared for CALFED Ecosystem Restoration Program. Sacramento, CA. 70 pp.

Van Cleve, F.B., C. Simenstad, F. Goetz and T. Mumford. 2004. Application of the "best available science" in ecosystem restoration: lessons learned from large-scale restoration project efforts in the US. Tech. Rep. 2004-01, Puget Sound Nearshore Partnership, Olympia, WA. 34 pp.

Williams, J.G. 2006. Central Valley salmon: a perspective on Chinook and steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science 4: http://repositories.cdlib.org/jmie/sfews/vol4/iss3/art2.

Appendix Materials

A1: Delta Vision

Delta Vision Goal 3: Restore the Delta ecosystem as the heart of a healthy estuary

Strategy 3.1: Restore large areas of interconnected habitats—on the order of 100,000 acres—within the Delta and its watershed by 2100.

Action 3.1.1: Increase the frequency of floodplain inundation and establish new floodplains.

Action 3.1.2: Restore tidal habitats and protect adjacent grasslands and farmlands throughout the Delta, with active near-term pursuit of restoration targets.

Strategy 3.2: Establish migratory corridors for fish, birds, and other animals along selected Delta river channels.

Action 3.2.1: Improve physical habitats along selected corridors by 2015.

Action 3.2.2: Provide adequate flows at the right times to support fish migrations, and reduce conflicts between conveyance and migration, by 2012.

Action 3.2.3: Immediately use the Central Valley Flood Protection Plan to identify areas of the San Joaquin River within and upstream of the Delta where flood conveyance capacity can be expanded.

Action 3.2.4: Using the National Heritage Area and regional economic development planning efforts, begin immediately to identify ways to encourage recreational investment along the key river corridors.

Strategy 3.3: Promote viable, diverse populations of native and valued species by reducing risks of fish kills and harm from invasive species.

Action 3.3.1: Reduce fish kills in Delta pumps by instituting diversion management measures by 2009, implementing near-term conveyance improvements by 2015, and relocating diversions.

Action 3.3.2: Control harmful invasive species at existing locations by 2012, and minimize or preclude new introductions and colonization of new restoration areas to non-significant levels.

Strategy 3.4: Restore Delta flows and channels to support a healthy Delta estuary.

Action 3.4.1: Charge the Department of Fish and Game with completing recommendations for in-stream flows for the Delta and high priority rivers and streams in the Delta watershed by 2012 and for all major rivers and streams by 2018.

Action 3.4.2: Develop and adopt management policies supporting increased diversion during wet periods, a joint effort of the State Water Resources Control Board, the Department of Fish and Game, the Department of Water Resources, and related federal agencies, to be completed by 2012.

Action 3.4.3: Adopt new State Water Resources Control Board requirements by 2012 to increase spring Delta outflow. Commence implementation no later than 2015.

Action 3.4.4: Adopt new State Water Resources Control Board requirements by 2012 to reintroduce fall outflow variability no later than 2015.

Action 3.4.5: Increase San Joaquin River flows between February and June by revising the State Water Resources Control Board's Vernalis flow objectives and the state and federal water projects' export criteria. Revise the flow objectives and criteria no later than 2012 and commence implementation as soon as possible thereafter.

Action 3.4.6: Provide short-duration San Joaquin River pulse flows in the fall starting by 2015.

Action 3.4.7: Reconfigure Delta waterway geometry by 2015 to increase variability in estuarine circulation patterns.

A2: Discussion of the DSM2 PTM

The documentation of the DSM2 PTM (referred to as "PTM" below) suggests several assumptions and a couple of inaccuracies in model formulation that will be described. The PTM uses a "quasi-3D" approach by using the "quasi-3-dimensional profiles" mentioned in the manuscript. These "quasi-3-dimensional profiles" are highly simplified and the treatment at junctions and open water areas assumes instant mixing. These points will be elaborated further.

a. The primary differences between 1D models and multi-dimensional models is that multi-dimensional models represent transverse velocities and lateral variability in longitudinal velocities. Therefore multi-dimensional models resolve flow structure in junctions and open water areas. In contrast, transverse velocities are not represented in 1D models and lateral variability in longitudinal velocities are not resolved in 1D models. Because lateral variability in velocity is not resolved in a one-dimensional model, a specific lateral structure is assumed in the PTM. The actual velocity distribution will depend primarily on the cross-sectional shape (bathymetry). The assumed velocity profile shape is uniformly applied and therefore does not account for actual cross-sectional shape.

b. The PTM documentation available at http://modeling.water.ca.gov/delta/reports/annrpt/1998/chpt4.html describes the treatment at junctions as follows: "When a particle reaches a junction, the decision has to be made as to where the particle is to go. Flows out of nodes include flows into channels, open water areas, agricultural diversions, and exports. Within the model, these locations are referred to as water bodies. The probability of a particle entering another water body is proportional to amount of flow entering that water body." Clearly the particle position (x,y,z) is ignored once a particle enters a junction (the point at which a particle enters a junction does not affect where it leaves the junction), losing all "quasi-3D" information. In reality the location at which a particle enters a junction of three or more channels will strongly influence where the particle exits the junction. For example, a water parcel ("particle") entering a junction on the southern side of a east-west oriented channel is far more likely to leave the junction in a southern channel than a northern channel. The PTM does not account for this.

c. The previous point is made more clearly in the documentation of treatment at open water areas: "Once a particle enters an open water area, it no longer retains its x, y or z position. The open water area is considered fully mixed. At the beginning of a time step the volume of the open water area the volume of water leaving at each opening of the open water area is determined. From that the probability of the particle leaving the open water area is calculated." Note that instant mixing is assumed in open water areas, so that longitudinal position (in addition to lateral and vertical position) is not accounted for in an open water area.

d. The assumed vertical velocity profile is provided on Figure 4.6 (http://modeling.water.ca.gov/delta/reports/annrpt/1998/chpt4fig4_6.html). This velocity profile is independent of any bottom roughness parameter (e.g. z_0) and the shape of this profile does not vary spatially. It would be more appropriate to use spatially variable bottom friction coefficients that are consistent with the bottom friction used in DSM2, which the article notes varies by region in ~50 regions of the Delta. Ideally the vertical profile would also adjust to account for stratification which may be important near Chipps Island under some flow conditions.

e. The vertical mixing (eddy diffusivity) is reported as $E_v=0.0067du^*$, where d is depth and u^* is friction velocity (shear velocity). No reference is provided, but this corresponds closely to the equation 5.3 in Fischer et al. (1979) for DEPTH-AVERAGED eddy diffusivity $E_v=0.067du^*$. The coefficients differ by an order of magnitude, perhaps suggesting that depth-averaged velocity was intended instead of friction velocity in the PTM documentation. In addition, as indicated in equation 5.2 in Fischer et. al (1979), the eddy diffusivity actually has an approximately parabolic vertical distribution in a uniform and steady open channel flow, described by $E_v(z) = kdu^*(z/d)[1-z/d]$, where k=0.4, z is the height above the bed, and d and u^* are as previously defined. This distribution in eddy diffusivity is likely to cause substantially different dispersion than vertically uniform eddy diffusivity.

f. Figure 4.8 of the PTM documentation provides a derivation of the particle tracking model equation. This equation is missing a necessary term. A more precise and concise derivation of treatment of diffusion in particle tracking models than Figure 4.8 can be found in Heemink & Blokland (1995) who show that the resulting equation is consistent with the advection diffusion equation. In the derived equation, an additional term is present (not used in the PTM) which is referred to as "correction term for spatial variations in diffusion" (Stijnen et al. 2006) or "apparent advection velocity" (Heemink & Blokland, 1995). Without this term, particles tend to "unmix" and concentrate in regions of low diffusivity. In the PTM applications, this "unmixing" probably will not occur because the vertical eddy diffusivity is (incorrectly) assumed to be uniform in the vertical. If a more realistic approach which accounts for vertical variability in eddy diffusivity is used, the missing term in the PTM formulation will become critically important.

Fischer H.B., List E.J., Koh R.C.Y., Imberger J., Brooks N.H. 1979. Mixing in Inland and Coastal Waters. New York: Academic Press.

Heemink, A.W., and Blokland, P.A., 1995. Note on Random Walk Models with Space Varying Diffusivity, Journal of Computational Physics 119: 388-389.

Stijnen, J.W., Heemink, A.W., and Lin, H.X., 2006. An efficient 3D particle transport model for use in stratified flow. International Journal for Numerical Methods in Fluids, 51, 331-350.

A3: Additional Important References Not Cited in the Draft

Alabaster, J.S. 1989. The dissolved oxygen and temperature requirements of king salmon, *Oncorhynchus tshawytscha*, in the San Joaquin Delta, California. Journal of Fish Biology 34:331-332.

Baker, P.F., Speed, T.P., Ligon, F.K. 1995. Estimating the influence of temperature on the survival of Chinook salmon smolts (*Oncorhynchus tshawytscha*) migrating through the Sacramento - San Joaquin River Delta of California. Canadian Journal of Fisheries and Aquatic Sciences 52:855-863.

Baker, P.F., Morhardt, J.E. 2001. Survival of Chinook salmon smolts in the Sacramento-San Joaquin Delta and Pacific Ocean. In: Brown, RL, editor. Fish Bulletin.2. p. 163-182.

Bottom, D.L., Jones, K.K., Cornwell, T.J., Gray, A., Simenstad, C.A.. 2005. Patterns of Chinook salmon migration and residency in the Salmon River estuary (Oregon). Estuarine, Coastal and Shelf Science 64:79-93.

Bottom, D. L., K. K. Jones, C. A. Simenstad, and C. L. Smith. 2009. Reconnecting social and ecological resilience in salmon ecosystems. Ecol. Society 14: 5. [online] URL: http://www.ecologyandsociety.org/vol14/iss1/art5/ (plus all the other papers in that special 'issue' on salmon resilience, at http://www.ecologyandsociety.org/issues/view.php?sf=34).

Bottom, D.L., Simenstad, C.A., Baptista, A.M., Jay, D.A., Burke, J., Jones, K.K., Casillas, E., Schiewe, M.H. 2005. Salmon at River's End: the role of the estuary in the decline and recovery of Columbia River salmon . Seattle: National Marine Fisheries Service.

Burke, J.L. 2005. Life histories of juvenile Chinook salmon in the Columbia River estuary : 1916 to the present. MS thesis, Oregon State Univ., Corvallis, OR.

Erkkila, L.F., Moffett, J.W., Cope, O.B., Smith, B.R., Nielson, R.S. 1950. Sacramento - San Joaquin Delta Fishery Resources: Effects of Tracy Pumping Plant and Delta Cross Channel. Sacramento, California: U.S. Fish and Wildlife Service. Special Scientific Report: Fisheries No. 56.

Gray, A., C.A. Simenstad, D.L. Bottom and T.J. Cornwell. 2002. Contrasting functional performance of juvenile salmon in recovering wetlands of the Salmon River estuary, Oregon USA. Restor. Ecol. 10: 514-526.

Grover, A., Kormos, B. 2009. The 2006 Central Valley Chinook age-specific run-size estimates. Santa Rosa, CA: California Dept. of Fish and Game, Scale Aging Program.

Grover, A., Kormos, B. 2009. The 2007 Central Valley Chinook age-specific run-size estimates. Santa Rosa, CA: California Dept. of Fish and Game, Scale Aging Program.

Hering, D.A. 2010. Growth, residence, and movement of juvenile Chinook salmon within restored and reference estuarine marsh channels in Salmon River, Oregon. MS thesis, Oregon State Univ., Corvallis, OR.

Høgåsen, H.R. 1998. Physiological changes associated with the diadromous migration of salmonids. Canadian Special Publication of Fisheries and Aquatic Sciences 127.

Jeffres, C.A., Opperma, J.J., Moyle, P.B. 2008. Ephemeral floodplain habitats provide best growth conditions for juvenile Chinook salmon in a California River. Environmental Biology of Fishes In press: DOI: 10.1007/s10641-008-9367-1.

Lindley, S.T., Grimes, C.B., Mohr, M.S., Peterson, W., Stein, J., Anderson, J.R., Botsford, L.W., Botton, D.L., Busack, C.A., Collier, T.K., Ferguson, J., Garza, J.C., Grover, A.M., Hankin, D.G., Kope, R.G., Lawson, P.W., Low, A., MacFarlane, R.B., Moore, K., Plamer-Zwahlen, M., Schwing, F.B., Smith, J., Tracy, C., Webb, R., Wells, B.K., Williams, T.H. 2009. What caused the Sacramento River fall Chinook stock collapse? National Marine Fisheries Service, Southwest Fisheries Science Center. NOAA_TM_SWFSC-447.

Lindley, S.T., Mohr, M.S. 2003. Modeling the effects of striped bass (*Morone saxatilis*) on the population viability of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*). Fishery Bulletin 101:321-331.

Lott, M.A. 2004. Habitat-specific feeding ecology of ocean-type juvenile Chinook salmon in the lower Columbia River estuary. MS Thesis, University of Washington, School of Aquatic and Fishery Science.

Maier, G.O., and C.A. Simenstad. 2009. The role of marsh-derived macrodetritus to the food webs of juvenile Chinook salmon in a large altered estuary. Estuaries Coasts 32: 984-998.

Marine, K.R, Cech, J.J. Jr. 2004. Effects of high temperature on growth, smoltification, and predator avoidance in juvenile Sacramento River Chinook salmon. North American Journal of Fisheries Management 24:198-210.

McEwan, D. 2001. Central Valley Steelhead. In: Brown, RL, Editor. Contributions to the biology of Central Valley salmonids, Fish Bulletin 179. Fish Bulletin 179.1. California Department of Fish and Game. p. 1-44.

Miller, J.A., Gray, A., and Merz, J. 2010. Quantifying the contribution of juvenile migratory phenotypes in a population of Chinook salmon (Oncorhynchus tshawytscha). Marine Ecology Progress Series. 408:227-240.

Moyle, P.B., Crain, P.K., Whitener, K. 2007. Patterns in the use of a restored California floodplain by native and alien fishes. San Francisco Estuary and Watershed Science vol. 5, issue 3, article 1:1-27. http://repositories.edlib.org/jmi/sfews/vol5/iss3/art1.

Myrick, C.A., Cech, J.J. Jr. 2001. Temperature effects on Chinook salmon and steelhead: a review focusing on California's Central Valley populations. http://www.cwemf.org/Pubs/index.htm.

Myrick, C.A., Cech, J.J. Jr. 2002. Growth of American River fall-run Chinook salmon in California's Central Valley: temperature and ration effects. California Fish and Game 88:35-44.

Myrick, C.A., Cech, J.J. Jr. 2004. Temperature effects on juvenile anadromous salmonids in California's Central Valley: what don't we know. Reviews in Fish Biology and Fisheries 14:113-123.

Olson, A.F., Quinn, T.P. 1993. Vertical and horizontal movements of adult Chinook salmon *Oncorhynchus tshawytscha* in the Columbia River estuary. Fishery Bulletin 91:171-181.

Quinn, T.P. 2005. The behavior and ecology of Pacific salmon and trout. Bethesda, Maryland: American Fisheries Society.

Satterthwaite, W.H., Beakes, M.P., Collins, E.M., Swank, D.R., Merz, J.H., Titus, R.G., Sogard, S.M., Mangel, M. 2009a. State-dependent life history models in a changing (and regulated) environment: steelhead in the California Central Valley. Evolutionary Applications In press: 10.1111/j.1752-4571.2009.00103.x.

Speed, T. 1993. Modeling and managing a salmon population. In: Barnett, V., Turkman, K.F., editors. Statistics for the Environment. John Wiley & Sons. p. 265-290.

Titus, R.G., Volkoff, M.C., Snider, W.M. 2004. Use of otolith microstructure to estimate growth rates of juvenile Chinook salmon from a Central Valley, California stock. In: Feyrer, F.L., Brown, R.L., Orsi, J.J., editors. Early life history of fishes in the San Francisco Estuary and watershed. American Fisheries Society Symposium 39. Bethesda, Maryland : American Fisheries Society. p. 181-202.

Volk, E.C., D.L. Bottom, K.K. Jones, and C.A. Simenstad. 2010. Reconstructing juvenile Chinook salmon life history in the Salmon River estuary, Oregon using otolith microchemistry and microstructure. Trans. Am. Fish. Soc. 139:535-549. [DOI: 10.1577/T08-163.1]

Williams, J.G. 2006. Central Valley salmon: a perspective on Chinook and steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science 4: http://repositories.cdlib.org/jmie/sfews/vol4/iss3/art2.